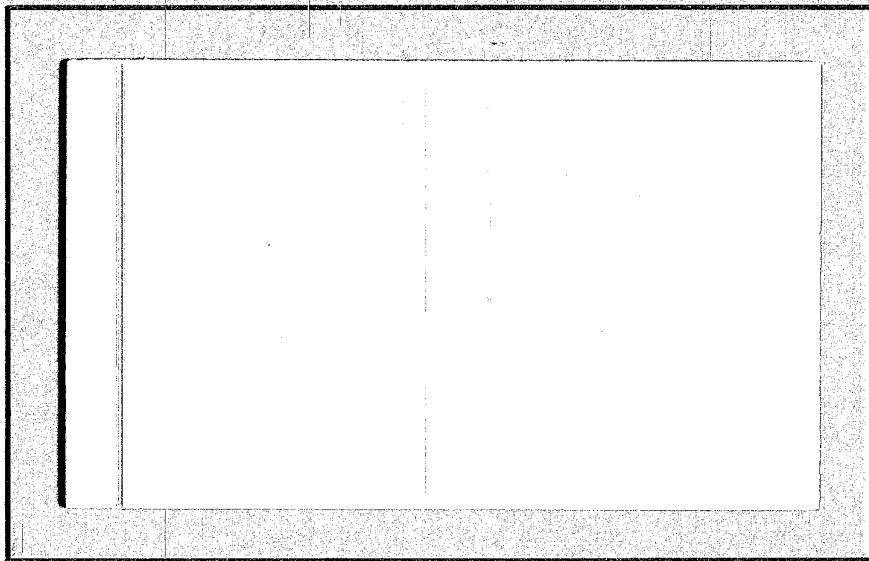


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FINAL ROTS FILE  
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JOB NO. 78-03639A  
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FINAL REPORT FILE  
EB-177A  
CACHING, UNDERWATER CONTAINER  
PROGRESS REPORT NO. 2

ON

TASK ORDER NO. M

October 14, 1960

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October 14, 1960

Dear Sir:

This is "Progress Report No. 2 on Task Order No. M", and it describes the results of the 6-month and 18-month inspections of the circular-cross-sectioned aluminum-alloy Type 3 containers which are being evaluated under fresh-water-immersion conditions at our Columbus, Ohio, and Daytona Beach, Florida, test sites. Twenty-seven containers were immersed at Columbus on May 7, 1958, and inspected on October 14, 1958, and October 1, 1959. Ten containers were immersed at Daytona Beach on May 19, 1958, and inspected on November 5, 1958, and November 4, 1959.

A description of the commercial fabrication of the containers, the leak-testing activities, the Columbus and Daytona Beach immersion test sites, the methods of immersion, and other details of the effort performed was presented in "Progress Report No. 1 on Task Order No. M", dated May 19, 1958.

#### CONTAINERS AT COLUMBUS

##### Summary

For the 6-month inspection, three bare, one anodized\*, and one butoxy-coated containers were retrieved for examination. For the 18-month inspection, four bare, three anodized, and one butoxy-coated containers were removed for examination. In the course of retrieval preparatory to both

\*The containers which are identified in this report as anodized were actually anodized, dyed, and sealed all over, i.e., on all of the interior as well as exterior surfaces.

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inspections, the containers had to be removed from buried positions in the mud bottom; in addition, at the 18-month inspection, we found that the anchor lines had broken and that the drop lines to the containers were so tangled that it was necessary to remove and relocate all of the containers after new anchor lines were installed.

The detailed 6-month examination of the five containers showed that the bare containers evidenced more corrosion damage than had been anticipated. However, the anodized and the painted containers were in excellent condition. The insides of four of the containers were dry; the fifth showed moisture, but a leak check revealed an insignificant leak. }

After 18 months, the one bare container examined for the first time showed only slight traces of corrosion. The corrosion damage which had been noted on the other bare containers after the first 6 months appeared to be unchanged. The anodized containers, however, showed scattered areas of shallow etching. The painted container had not changed. The insides of all except one of the previously opened containers were dry. However, the insides of two of the three containers opened for the first time showed excessive moisture. Subsequent leak checks revealed no significant leaks. Consequently, pending the results of future inspections after additional periods of immersion, it is tentatively assumed that the excessive moisture noted represents the moisture in the air trapped within the containers at the time they were closed, preparatory to immersion; on the day that these containers were prepared for immersion and were immersed, the weather was quite rainy.

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Bare Container No. 596-Month Inspection

An examination of the shell showed that considerably more corrosion had taken place than had been anticipated. Near the bottom of the shell, two deep pits were found that were approximately  $1/32$  inch deep. On the part of the shell which had been down in the mud were areas approximately 4 inches square which were definitely marked by corrosion. No deep pits were found in these areas, but it appeared that the shell had been in contact with some substance in the mud that had caused localized corrosion. The wrought handles were heavily pitted, although the pits in general were not over 0.020 inch deep. This was observed on the handles which were at the top of the container when submerged; the handles at the bottom of the container, i.e., in the mud, exhibited only slight corrosion. The retainer clip and lid were readily removed.

Although there was no visible moisture in the container, the silica gel desiccant was pink, indicating considerable moisture pickup. A subsequent weight check revealed an increase in weight of 13 grams, corresponding to a 24 per cent increase in weight, which was considered significant. The steel specimen in the container had been polished on one side and sandblasted on the other. The sand-blasted side showed traces of rust; the polished side exhibited spots of rust approximately  $1/4$  inch wide, with the total rusted area representing approximately 5 per cent of the polished area. A scribe was used to mark most of the rusted areas, so that at the next inspection, we could note whether additional rusting had taken place.

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In view of the rusting of the steel specimen and the 2<sup>1</sup>/<sub>4</sub> per cent increase in the weight of the desiccant, it appeared that a small leak was present. After considering these results, we decided that Container No. 59 should be leak checked to determine, if possible, the cause of the rusting of the steel specimen and the high moisture content which had been indicated by the desiccant. Subsequently, the container was again removed from the water for examination and leak testing. Upon opening the container, we found that the new desiccant cartridge had been broken, but that the loose silica gel crystals were blue and the interior of the container appeared to be dry.

The container was then leak checked by the soap-bubble and cold-water leak testing methods. The soap-bubble test revealed one small leak in the longitudinal welded seam on the shell at a point near the flange end of the container; the cold-water test showed no leakage at that point, or elsewhere.

From a comparison of this result with the data obtained from our previous leak-calibration and testing work, it was decided that the leak in this container corresponded to a leak rate of less than  $9 \times 10^{-4}$  atm-cc/sec. This leak rate is smaller than that of the calibrated leak in Container No. 33, described below. Since no evidence of a moisture increase was found in Container No. 33, and since no evidence of leakage was noted in the re-examination of Container No. 59, Container No. 59 was returned to the test site and re-immersed.

#### 18-Month Inspection

An examination of the relatively badly corroded areas on the shell that were noted at the 6-month inspection revealed no increase in corrosion

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damage at the 18-month period. The cast flange and lid, and the wrought retainer clip showed more corrosion than previously. Corrosion product was clumped at each corrosion point and shallow pitting was noted under each clump. All of the handles were free. The retainer clip and lid were removed readily.

The steel specimen showed no increase in rust deposit and the silica gel was blue. Subsequent weight measurements of the desiccant cartridge showed an increase in weight of 3.2 grams, corresponding to a 6 per cent weight increase, which is considered to be a normal gain. Any increase of up to approximately 8 per cent in the weight of the desiccant cartridge is considered to be insignificant.

The container was re-immersed.

Bare Container No. 33

6-Month Inspection

The condition of the shell of this container was generally similar to that of Container No. 59 at the 6-month period. However, no deep pits were found and the corroded areas in general were not so large. The corroded condition of the handles was similar to that described above for Container No. 59. The retainer clip and lid were readily removed.

The interior appeared to be dry and the desiccant was blue. Subsequent weight measurements showed an increase in weight of 1.54 grams, corresponding to a 3 per cent increase in weight. The steel specimen, which had been ground on both sides, exhibited no rusting on either side.

The container was re-immersed.

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18-Month Inspection

The various corroded areas and points previously observed on different parts of the container showed no increase in corrosion damage. One deep pit, approximately 1/16 inch deep, was found on the cast lid. The rest of the lid, the cast flange, and the wrought retainer clip exhibited slight corrosion etching at a few points, where the corrosion product was collected in little clumps. Some shallow etching was also noted at the O-ring contact line inside the flange groove. The weld metal appeared to be in excellent condition. The handles were all free. The retainer clip and lid were readily removed.

The desiccant removed from this container was blue and showed a weight increase of 3 grams, i.e., approximately 6 per cent. The steel specimen showed no rust.

The container was re-immersed.

Bare Container No. 556-Month Inspection

The exterior of the shell appeared similar to that of Container No. 33, and only one noticeable pit was located. This pit was near the top of the container and appeared to be approximately 0.010 inch deep. The handles which were located on the top of the container when submerged were found to be considerably corroded, particularly in the corners where high stress levels would be expected; this was noted for the other bare containers examined. Many of these handle pits were almost 1/16 inch deep. Otherwise,

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the container exterior was in good condition. Also, the handles were all free, and the retainer clip and lid were readily removed.

The interior of the container appeared to be dry. The steel specimen, which was ground on both sides, showed no signs of rust. The desiccant cartridge, when weighed, indicated a weight increase of about 3 grams, corresponding to 6 per cent.

The container was re-immersed.

#### 18-Month Inspection

The shell appeared to be in the same general condition as was noted above after 6 months of exposure. The wrought retainer clip and handles, and the cast flange and lid showed slightly increased corrosion damage, similar to that found on Container No. 59. The handles were all free, and the retainer clip and lid were readily removed.

The steel specimen and desiccant showed no evidence of excessive moisture inside the container. The desiccant recorded a weight increase of about 6 per cent, or 3.2 grams.

The container was re-immersed.

#### Bare Container No. 31

#### 18-Month Inspection

In accord with the over-all inspection plan, this was not one of the containers inspected after 6 months of exposure.

However, the 18-month inspection showed three shallow pits and some roughening or etching of the shell. The weld metal was in fine condition.

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The cast parts had a number of small corrosion deposits scattered over the surfaces, with extremely small pits located underneath each deposit. Three of the handles were free and one handle was broken off. Otherwise, the retainer clip and handles were pitted in a manner similar to that noted on the other bare containers. The retainer clip and lid were readily removed.

The inside of the container appeared dry and the desiccant was blue. The steel specimen showed no signs of rusting. A weight measurement of the desiccant showed an increase of about 7 per cent, or 4 grams.

The container was re-immersed.

Anodized Container No. 10

6-Month Inspection

The anodized exterior of this container appeared to be in excellent condition. No pits were found on the shell or on the handles, and the handles were even more free than those of the bare containers. A few, small clumps of white corrosion product and a few shallow pits were observed on the cast lid. However, it was obvious that the anodized, dyed, and sealed finish had provided anticorrosion protection for this container. The retainer clip and lid were readily removed. When this container was opened, it was found that the desiccant cartridge had been broken during the examination of the shell, and no weight check on the desiccant was possible. The desiccant crystals were pink, so there may have been excessive moisture in the container. However, the steel specimen, which had been ground on both sides, showed no evidence of rust.

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An examination of the inside of the container showed a spot near the bottom that appeared to be a possible leak where white corrosion products might have formed. However, further examination revealed that the light-colored spot was an area of bare metal, i.e., a small area which had not been anodized. The Sponsor recollected that one of the containers had had a bubble in and around the bottom of the interior during anodizing and this bubble may have prevented anodizing at one spot. It appeared that this may have been that container, although we had no record with which to substantiate this deduction. A subsequent check of the location of the leak which had been detected in this container during the calibration leak tests disclosed that the bare spot was located a considerable distance from the calibrated leak.

The container was re-immersed.

#### 18-Month Inspection

A little corrosion in the form of shallow etching was found on the shell of this container. A few clumps of corrosion product were noted on the lid and flange, as had been observed in the 6-month inspection. Light etching was noted on the lid lugs. The dye had apparently leached out of the retainer clip; the clip was almost an aluminum color. All of the handles were free, and the retainer clip and lid were readily removed.

The silica gel cartridge was very pink; in view of this and other indications of high moisture content, a weight measurement was not made. The steel specimen was rusted uniformly on the sandblasted side to the extent of about 80 per cent coverage, and rust covered about 10 per cent of the

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polished side. The inside of the container appeared dry. But, because of the high-moisture indication by the desiccant and the steel specimen, this container was returned to the laboratory and checked for leaks. This check revealed that the original calibrated leak in this container had a leak rate of  $1.5 \times 10^{-5}$  atm-cc/sec. This leak rate is far below that of the calibrated leak in Container No. 33 (described above); therefore, it was decided that the calibrated leak in Container No. 10 could not be considered to have been the source of the high moisture content of the air in the container. Although this question was not resolved at this time, the container was re-immersed.

Anodized Container No. 37

18-Month Inspection

There had been no 6-month inspection made on this container.

The shell of this container appeared to be in very good condition after 18 months of exposure. Three of the handles were frozen by corrosion products, but were easily broken loose by hand; the fourth handle was free. The lid was "stained" with very-light-colored corrosion spots, in numerous small localized spots on the outside and, to some extent, on the interior surfaces. Three spots of shallow pitting were noted on the lid, and one pit, 1/16 inch deep, was found at the corner of one of the lid lugs. Scattered white corrosion product was noted along the longitudinal welded seam on the interior of the container, and the dye was found to be leaching out of the retainer clip.

The retainer clip and lid were readily removed. The desiccant was very pink; no weight measurement was performed. The steel specimen was

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rusted for between 5 and 10 per cent of the surface on one side and along one edge on the other side. Again, because of the high-moisture-content indication, we returned this container to the laboratory for a leak check. No leaks were found. The container was subsequently re-immersed.

Anodized Container No. 46

18-Month Inspection

Since both of the anodized containers which had been inspected at the end of 18 months of exposure showed indications of high moisture content, we decided to inspect a third anodized container. The retainer clip and lid were readily removed.

Upon opening Container No. 46, we found that the steel specimen was rusted over approximately 70 per cent of the surface on one side and 10 per cent of the surface on the other side. A film of moisture was noted on the lower side of the ballast bars and the desiccant was very pink; the weight change was not measured. No signs were observed of corrosion on the inside surfaces of the container that would suggest a leak. However, this container was returned to the laboratory and leak checked. No leaks were found. The container was re-immersed.

Painted Container No. 30

6-Month Inspection

The painted shell and lid were covered with blisters which ranged from 1/16 to 1/4 inch in diameter. In general, the blisters on the top of

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the container when submerged were larger and farther apart than those on the container bottom which had been buried in the mud. Several blisters were opened and the metal underneath was found to be unpitted in every case. All of the blisters which were opened contained water\*. The handles were even more free than those of the unpainted containers. One of the lid lugs of this container broke off while we were removing the lid. An examination of the fracture showed that the lug had been cracked previously. The retainer clip and lid were readily removed.

The interior appeared to be dry, and the desiccant was blue. A check showed a desiccant weight increase of 1.3 grams, corresponding to 2.5 per cent. The steel specimen, which had been ground on one side and sandblasted on the other, showed only a very slight trace of rusting on the sandblasted side.

The container was re-immersed.

#### 18-Month Inspection

The coating at the end of 18 months looked the same as it did after 6 months of exposure. All of the handles were free, and the retainer clip and lid were readily removed. The interior of the container appeared dry; the desiccant was blue, and the steel specimen appeared the same as was noted at the 6-month inspection.

It was observed that the coating had been chipped off directly below the handles to which the harness rope had been tied. The container was re-immersed.

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\*During the next inspection, there may be merit in checking the pH of the water within the blisters, in an attempt to obtain information which may be of some interest.

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CONTAINERS AT DAYTONA BEACH

Summary

For the 6-month inspection at Daytona Beach, three containers - one bare, one anodized, and one butoxy-coated - were retrieved and examined. At the 18-month inspection, we removed and examined one bare, two anodized, and one butoxy-coated containers. During the retrieval operation, it was found that these containers, like those in Columbus, were partially buried in the mud.

A detailed examination of the three containers after the 6-month period showed that the bare container evidenced some corrosion, but not so much as that noted on the bare containers immersed at Columbus. The anodized and the painted containers were in excellent condition, and showed no corrosion damage. The paint coating was blistered, but appeared to be in good condition otherwise. The interiors of the bare and anodized containers were dry, and the lids were easily removed and replaced; the painted container was not opened for inspection.

After the 18-month exposure, the detailed examination of the four containers showed some additional pitting, but this was not severe. The two anodized containers showed traces of corrosion. The painted-container coating was blistered, but seemed to be in good condition. The interiors of the bare and both anodized containers appeared dry. The bare and one anodized containers showed no indication of moisture by the desiccant cartridges, which were colored blue; the desiccant in the other anodized container was a light pink in color. The painted container was again not opened.

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Bare Container No. 176-Month Inspection

The upper surface above the mudline of this container was covered with a heavy layer of green algae. Below the mudline, the surface was covered with a network of tightly adherent, threadlike filaments which appeared to be a fresh-water colonial organism, but no specific identification was made.

After washing the container, we found numerous very minute pits in the shell and each of these was surrounded by a halo of white corrosion product. These pits were most numerous just above the mudline. The retainer clip, handles, and lid also showed traces of shallow etching. The handles were all free, and the retainer clip and lid were readily removed.

The interior of the container appeared to be dry, and there was no indication of rust on the steel specimen, which had been ground on both sides. The desiccant was blue, and subsequent weighing revealed an increase in weight of 5.1 grams, corresponding to 9.3 per cent. Although this was larger than the average increase noted in the Columbus containers, it was still not considered to be abnormal.

The container was re-immersed.

18-Month Inspection

The surface of the container was covered with green algae and the network of threadlike filaments as was described above. The same shallow pitting with the associated halo of white corrosion product was noted. Two

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pits were found on the longitudinal welded seam about 16 inches below the flange; these measured 0.007 inch and 0.011 inch deep.

There were a number of small areas of shallow etching on the retainer clip and handles, and two spots of shallow etching on the lid. Wherever this etching was noted, there was a small clump of firm white corrosion product directly over the corroded area. The handles were all free, and the retainer clip and lid were readily removed.

The interior of the container appeared to be dry and the desiccant was blue. There was no evidence of rust on the polished steel specimen. A subsequent weight measurement on the desiccant cartridge showed a 5.4 per cent increase in weight (3.04 grams).

The container was re-immersed.

Anodized Container No. 56

6-Month Inspection

This container was also covered with a growth of green algae and colonial organism; however, the coating was not so heavy as that formed on Container No. 17, described above. The anodized coating was found to be in excellent condition on the shell, handles, and lugs, except for a 1/16-inch-diameter spot approximately 1/2 inch from the bottom of the shell, where the contacts had been clamped to the container during anodizing. The metal had been deeply scored by the clamping arrangement and may be corroding slightly in the base of the depressions.

A trace of white corrosion product was found at the contact points between the lid and the retainer clip, and small pits estimated to be

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1/64 to 1/32 inch deep were found beneath the corrosion deposits. Elsewhere on the flange were numerous white or metallic spots which appeared to be points where the dye had failed to penetrate the anodizing. Several corrosion deposits approximately 1/8 inch in diameter and 1/16 inch thick were found on the flange, but no pitting was detected under these. All of the four handles were free, and the retainer clip and lid were readily removed.

The interior of this container appeared to be dry and no evidence of rust was found on the steel specimen (which had been ground on one side and sandblasted on the other). However, a very slight dusting of rust powder was observed on the lower half of the container interior. The desiccant removed from this container was blue, and showed a weight increase of 6.1 grams, corresponding to 10.7 per cent.

The container was re-immersed.

#### 18-Month Inspection

The shell surface above and below the mudline were coated as described above. After scrubbing the container with a soft brush, we found that the container appeared almost exactly as it had after 6 months of immersion, as described above.

The interior of the container was dry, and no rust was detected on either the polished or sandblasted side of the steel specimen. The silica gel cartridge was smashed during handling of the container, but the silica gel crystals were blue; no weight measurement was attempted. A light dusting of rust was noted on the lower half of the container interior.

The container was re-immersed.

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Anodized Container No. 5318-Month Inspection

This was the first inspection of this container. After 18 months of immersion, the dark-green dye had faded to a pale olive-green color over the entire container except for portions of the handles.

Many minute white spots were found on the outer surface of the lid and flange, but there was no evidence of corrosion at these points. A few spots of white corrosion product, 1/8 inch in diameter, were noted on the flange, but no pits were found under these spots.

At the lower end of the shell where the electrodes had been clamped in anodizing, a definite white-corrosion-product deposit was found in the bottom of the scoring. We also found one very shallow pit on the lower rim of the shell, where the anodizing had been scraped off. The four handles were all free, and the retainer clip and lid were readily removed.

The interior of the container appeared dry and the polished steel specimen was bright on both sides, except for one 1/16-inch-diameter rust spot on one side. The desiccant was pink, and a subsequent weight measurement showed a 5.0-gram increase, corresponding to 8.7 per cent.

Painted Container No. 546-Month Inspection

The paint coating on this container was severely blistered. The blisters ranged in size from pinpoint to 1/16-inch in diameter on the shell, and from pinpoint to 3/16-inch in diameter on the bottom and handles.

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All of the blisters were unbroken; however, two were opened with a probe and found to be filled with water. There was no evidence of corrosion under the two opened blisters. The numerous blisters on the lid were larger than those on the other areas of the container; the blisters on the retainer clip and handles were smaller and located relatively close to one another. The four handles were free.

The rubber bumper on this container was slipped off at one side to check the paint coating underneath; in the process, the coating on a 1/2-inch by 1-inch area in the bumper groove was peeled to the bare metal.

This container was not opened, and was re-immersed.

#### 18-Month Inspection

The appearance of this container after 18 months of exposure was almost exactly like that after 6 months. The paint coating was still severely blistered, and the blisters ranged in size from pinpoint to 1/8-inch in diameter on the shell, and from pinpoint to 3/16-inch in diameter on the bottom and handles. The blisters were unbroken, but two more were opened and were found to contain water. There was no evidence of corrosion under these two blisters. The distribution of the blisters on the retainer clip and handles was very dense; the blisters on the lid were slightly larger than those on the shell.

The bumper was slipped off at one side; but, no attempts were made to examine the peeled area in the bumper groove that was commented on in connection with the 6-month inspection. The handles were free.

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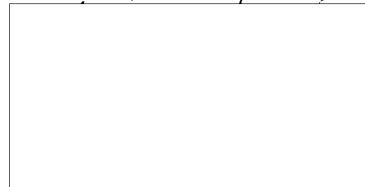
The container again was not opened for an interior inspection, and was re-immersed.

FUTURE WORK

It is contemplated that the next inspection of selected containers, after about 30 months of fresh-water immersion, will be scheduled for October, 1960.

We would appreciate any comments which you or your associates might care to make with regard to these efforts.

Sincerely,



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ABW:mlm

In Triplicate

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